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Transportation ontology definition and application for the content personalization of user interfaces

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ABSTRACT

Ontologies have been largely exploited in many domains and studies. In this paper, we present a new application of a domain ontology for generating personalized user interfaces for transportation interactive systems. The concepts, relationships and axioms of transportation ontology are exploited during the semi-automatic generation of personalized user interfaces. Personalization deals with the capacity of adaptation of a user interface, reflecting what is known about the user and the domain application. It can be performed on the interface container presentation (e.g., layout, colors, sizes) and in the content provided in their input/output (e.g., data, information, document). In this paper, the transportation ontology is used to provide the content personalization. This paper presents the ontology and how it is used for the personalization of user interfaces for developing transportation interactive systems by model-driven engineering.

1. Introduction

A user from the transportation system is, for instance, a passenger who seeks assistance about moving from one place to another. This simple daily activity deals with the complexity of multimodality of transportation (i.e., the possibility of using multiple transportation modes, such as bus and subway, for a single itinerary between the origin and the final destination). For a better assistance to the passenger, it is also important to present all the possible services related to the itinerary (e.g., information about restaurants and banks that the user has access on his/her journey). All this knowledge must be considered for developing useful transportation systems.

Several kinds of computing platforms (e.g., tablets, desktop, mobile phones) and medias (e.g., audio, video, image, text) simultaneously were explored for developing transportation systems to support user needs. In this daily activity, a typical scenario is, for example, a person who plans her/his trip by train at home with a PC; then, while going to the train station, she/he gets stuck in a traffic jam and checks train schedules to find another departure time, using a PDA, and changes his/her reservation. When arriving at the train station, she/he goes to the kiosk and uses terminal to get the ticket. In this simple example, three kinds of platforms were used and different context of use have to be taken into account. This flexibility makes the user even more demanding. The solution is to conquer the users by developing customizable systems adapted to any electronic device and providing particularized information to them in a way that she/he can save time and be more productive, thus providing personalized software systems.

Scenarios like that motivated us to work on the definition of personalized interactive systems for the transportation domain. Model-driven architecture (MDA) (OMG, 2003) has been shown to be an appropriate approach for the design and code of the software system and their user interfaces (UI) to address those challenges. In MDA, models play a more direct role in software production, manipulation and transformation by machines. UI can be specified with a high level of abstraction, and the final UI are transformed for different platforms.

Using MDA, we developed an approach for generating personalized UI (Bacha, Oliveira, & Abed, 2011a). To that end, we defined a transportation ontology that organizes the knowledge of the domain and a context model to capture the information about the user. This ontology is mapped with context elements to allow personalization. Both the ontology and the context are used in the approach for generating personalized UI. In this paper, we detail how the ontology is applied (i.e., concepts, relationships and axioms) to make it possible to personalize UI. Details about the UI generation using MDA can be found in other papers (Bacha, Oliveira, & Abed, 2011b; Bacha, Oliveira, & Abed, 2011c; Bacha et al., 2011a; Bacha et al., 2011b).

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This paper is organized as follows. Section 2 briefly defines ontology and presents its application in the transportation domain. Then, Section 3 describes the fundamentals of personalization. Section 4 presents our approach for generating personalized UI to highlight the content personalization proposed in this paper. Section 5 provides the transportation ontology, and Section 6 shows how it is used for personalization. Finally, Section 7 offers our conclusions.

2. Ontology: definition and application in the transportation domain

Ontology is a description of entities and their properties, relationships, and constraints expressed via axioms (Grüninger & Fox, 1995). Domain ontologies (Guarino, 1998) express conceptualizations that are specific for a particular domain (e.g., medicine or transportation). They put constraints on the structure and contents of domain knowledge. For example, in the medical domain, ontologies would describe the concept, ''symptom'', and that symptoms are a manifestation of a disease. Ontologies have been exploited in many studies and domains (e.g., medicine (Arsene, Dumitrache, & Mihu, 2011; Rodriguez-Gonzalez et al.,2012; Zhou et al., 2004)), education (Chu, Lee, & Tsai 2011; Jia et al., 2011; Macrics & Georgakellos, 2006; Versin, Ivanovic, Klašnja-Milicévic, & Budimac, 2012), and logistics (Anand, Yang, van Duin, & Tavasszy, 2012; Giménez, Vegetti, Leone, & Henning, 2008; Grubic & Fan, 2010)) using their capacity to promote sharability of knowledge bases, knowledge organization, and interoperability among systems. Many studies can also be found in the transportation domain with various goals.

Becker & Smith (1997) defined an ontology for multi-modal military transportation planning and scheduling. Their ontology focuses on concepts about transportation services, activities, resources (i.e., vehicles, crews, terminal facilities) and constraints, which dictate how, when, by whom and where transportation activities (e.g., deployment, evacuation) can be executed. This ontology considers different transport modes, but it is not complete enough to support the development of travel planning systems since it deals only with military transportation activities.

Timpf (2002) described two ontologies of ''wayfinding'' with multiple transport modes in an urban area based on two perspectives: the traveler and the public transportation system. His work identified the concepts to define ontology from the description of directions given verbally by five people. At the end, he obtained a list of concepts of both perspectives and showed that one is a subset of the other. The research of seeking for concepts from the direction descriptions was very detailed; however, the list of concepts obtained are only a part of the ontology definition, since proprieties, relationships and axioms were not defined.

In another similar work, Wang, Ding, & Jiang (2005) developed a system based on public transportation ontology. Based on user inputs (i.e., origin, destination and priorities), the software system searches for bus stops, using a spatial radius search. The algorithm finds journeys based on origin-destination pairs by bus route identification, using a relationship matrix between route and station. Therefore, this work does not consider either the transportation multi-modality or the possible associated services that can be offered to the user.

Niaraki & Kim (2009) proposed a road segment ontology to determine an impedance model of road geographic information system and intelligent transportation system. This impedance model computes the amount of cost, or resistance, expected to pass through a link from its origin node to destination node. They defined a road segment ontology based on the user preferences criteria and context (or environmental) criteria. From this ontology, they defined an hierarchical structure divided into two branches: one related to the user criteria (e.g., information about tourist attractions and preferences) and the other related to the context criteria (e.g., weather and safety). The impedance is calculated using the ontology information.

Yang & Wang (2012) introduce an urban traffic ontology into information integration, describing the semantic rules and relationships, as well as the regulations of semantic mergence and the selection and verification of semantic fusion. They show that the semantic fusion based on ontology, increases the effect and efficiency of the urban traffic information integration, reduces the storage quantity and improves query efficiency and information completeness. They look for how to rapidly build ontology with massive real time traffic information and how to effectively analyze required information with the ontology.

Barrachina et al. (2012) define a vehicle accident ontology, which combines the information collected when an accident occurs and the data available in the general estimates system's accident database. Their goal is to define a common vocabulary for the interoperability of transportations systems that will be used in the future to support vehicle accidents. The ontology organizes the knowledge about the accident (e.g., coordinates, speed), the vehicle (e.g., chassis, make, model), the occupant (e.g., identity, age, sex), and the environment (e.g., speed limit, surface condition, weather).

This paper proposes a different application of transportation ontology to support the personalized UI generation, working on the definition of a travel planning ontology since this is a common task in which several applications have been developed for different platforms to support their users.

3. Personalization

Personalization is defined as ''the ability to provide content and services that are tailored to individuals based on knowledge about their preferences and behavior'' (Hagen, Manning, & Souza, 1999). ''Delivering to a group of individuals, relevant information that is retrieved, transformed, and/or deduced from information sources'' (Won, 2002). Garía-Barrios, Mödritscher, & Gütl (2005) define personalization as ''adaptation towards a named user for which an internal and individual model is needed''. Simonin & Carbonell (2006) describe personalization as ''the dynamic adaptation of the interface to the profile''. In general, personalization deals with the ability of adapting a UI considering some information related to this user.

Personalization can take many features into account and can be applied to many levels (Chevalier & Julien, 2003; Kobsa, 2001), as follows:

- Personalization of the presentation – this category of personalization tries to adapt the style and format of interaction interface components (e.g., buttons, text fields) based on the user needs and their context. Anli (2006) and Brossard, Abed, & Kolski (2011) call this ''container personalization'', and consider similar to ''interface plasticity'' defined by Thevenin & Coutaz (1999).
- Personalization of the structure – this category of personalization is applied to the links between a website's pages. For example, some links may be proposed with special notation or included in the first position in a list of links, according to their relevance.
- Personalization of functionalities – this category of personalization makes available only the functions necessary for a specific user to answer a task by automatically adapting the system.
- Personalization of the navigation – this category of personalization guides the user to the right information, by avoiding irrelevant pages.